

CENTERS FOR DISEASE CONTROL

August 26, 1988 / Vol. 37 / No. S-7

MMWR

Supplement

MORBIDITY AND MORTALITY WEEKLY REPORT

**NIOSH
Recommendations
for
Occupational Safety
and
Health Standards
1988**

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES

Public Health Service

National Institute for Occupational Safety and Health
Centers for Disease Control
Atlanta, Georgia 30333

Supplements to the MMWR are published by the Epidemiology Program Office, Centers for Disease Control, Public Health Service, U.S. Department of Health and Human Services, Atlanta, Georgia 30333.

SUGGESTED CITATION

Centers for Disease Control. Recommendations for Occupational Safety and Health Standard. MMWR 1988;37 (suppl. no. S-7): [inclusive page numbers].

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Copies can be purchased from Superintendent of Documents, U.S. Government
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INTRODUCTION

Acting under the authority of the Occupational Safety and Health Act of 1970 (Public Law 91-596), the National Institute for Occupational Safety and Health (NIOSH) develops and periodically revises recommendations for limits of exposure to potentially hazardous substances or conditions in the workplace. NIOSH also recommends preventive measures designed to reduce or eliminate the adverse health effects of these hazards. In formulating these recommendations, NIOSH evaluates all known and available scientific information relevant to the potential hazard. The recommendations are then published and transmitted to the Occupational Safety and Health Administration (OSHA) or the Mine Safety and Health Administration (MSHA) of the U.S. Department of Labor for use in promulgating legal standards.

NIOSH recommendations are published in a variety of documents. Criteria documents specify a NIOSH recommended exposure limit (REL) and appropriate preventive measures designed to reduce or eliminate adverse health effects.

Special hazard reviews, occupational hazard assessments, alerts, and technical guidelines are other types of NIOSH documents that complement the Institute's recommendations for standards. These documents provide safety and health assessments of specific problems associated with a given agent or hazard, and they recommend appropriate control and monitoring methods. Although these documents do not supplant the more comprehensive criteria documents, they are prepared to assist OSHA or MSHA in the formulation of regulations.

NIOSH periodically presents testimony before various Congressional committees and at regulatory hearings convened by OSHA or MSHA. The testimony always includes the current NIOSH policy concerning the hazard in question.

NIOSH Current Intelligence Bulletins (CIBs) review and evaluate new and emerging information on occupational hazards. These bulletins may draw attention to a formerly unrecognized hazard, report new data on a known hazard, or disseminate information on hazard control.

The recommendations listed in this summary are based on existing NIOSH policy as previously published in any of the forms listed above. The intent of this table is to provide a rapid reference to the most recent NIOSH REL or other recommendation for each potential hazard. The current OSHA permissible exposure limit (PEL) or standard is also presented. Unless otherwise noted in the table, the NIOSH recommendations were originally published in criteria documents.

Note to Readers:

Copies of NIOSH publications are generally available from the U.S. Government Printing Office and the National Technical Information Service. Single copies of these publications may be obtained (while the supply lasts) from

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Definitions of Abbreviations and Terms

Action level	the exposure concentration at which employers must initiate certain provisions of the NIOSH recommended standard such as periodic measurements of worker exposure, training of workers, and medical monitoring
Ca	agent recommended by NIOSH to be treated as a potential human carcinogen
CD	criteria document
CFR	Code of Federal Regulations
CIB	Current Intelligence Bulletin
CNS	central nervous system
dBA	decibels measured on the A scale, which approximates the response of the human ear
ECG	electrocardiogram
J/cm ²	joules per square centimeter
μm	micrometer
μg/m ³	micrograms per cubic meter
mg/m ³	milligrams per cubic meter
mppcf	millions of particles per cubic foot
MSHA	Mine Safety and Health Administration
mW/cm ²	milliwatts per square centimeter
NIOSH	National Institute for Occupational Safety and Health
nm	nanometer
OSHA	Occupational Safety and Health Administration
PCBs	polychlorinated biphenyls
PCDDs	polychlorinated dibenzo- <i>p</i> -dioxins
PCDFs	polychlorinated dibenzofurans
PEL	permissible exposure limit (OSHA)
ppb	parts per billion
ppm	parts per million
REL	recommended exposure limit (NIOSH)
(Skin)	potential contribution to overall exposure by the cutaneous route, including mucous membranes and eyes
TCDD	2,3,7,8-tetrachlorodibenzo- <i>p</i> -dioxin
TWA	time-weighted average
WL	working level
WLM	working level month



NIOSH RECOMMENDATIONS FOR OCCUPATIONAL SAFETY

Potential Hazard and Source for NIOSH Recommendation*	OSHA PEL/Standard	REL†/Other Recommendations
2-Acetylaminofluorene (NIOSH testimony at OSHA hearing, September 1973)	No PEL; cancer-suspect agent; stringent workplace controls, recordkeeping, and medical monitoring required; 29 CFR 1910.1014	Ca; use 29 CFR 1910.1014
Acetylene (July 1976)	2,500 ppm (10% of lower explosive limit); 29 CFR 1915.12	No exposure >2,500 ppm (2,682 mg/m ³)
Acrylamide (October 1976)	0.3 mg/m ³ , 8-hr TWA (Skin)	0.3 mg/m ³ TWA
Acrylonitrile (January 1978; revised March 1978 as part of NIOSH testimony at OSHA hearing)	2 ppm, 8-hr TWA; 10 ppm ceiling (15 min) (Skin); 29 CFR 1910.1046	Ca; 1 ppm, 8-hr TWA; 10 ppm ceiling (15 min) (Skin)
Aldrin/dieldrin (Special Hazard Review, September 1978)	0.25 mg/m ³ , 8-hr TWA (Skin)	Ca; reduce exposure to lowest reliably detectable concentration
Alkanes (C5-C8) (March 1977)	All are 8-hr TWA values: pentane, 1,000 ppm (2,950 mg/m ³); n-hexane, 500 ppm (1,800 mg/m ³); n-heptane, 500 ppm (2,000 mg/m ³); octane, 500 ppm (2,350 mg/m ³)	All are TWA values: pentane, 120 ppm (350 mg/m ³); hexane, 100 ppm (350 mg/m ³); heptane, 85 ppm (350 mg/m ³); octane, 75 ppm (350 mg/m ³); mixtures should not exceed 350 mg/m ³ TWA.

(continued on next page)

*Dates in parentheses indicate when the NIOSH recommendation was published or when the published in criteria documents unless otherwise noted.

†NIOSH TWA recommendations are based on exposures up to 10 hours unless otherwise noted.

‡Health effects cited are for humans unless otherwise noted.

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Health Effect(s) Considered ¹	Comments
Potential for cancer in humans; has produced tumors of the liver, bladder, lungs, pancreas, and skin in animals	None
Asphyxia	Check for and inform workers of contaminants such as arsine and phosphine
Skin, eye, and nervous system effects	Prevent skin and eye contact
Brain tumors, lung and bowel cancer	Periodic chest X-ray required; make first-aid and medical kits available during use; prevent skin contact
Potential for cancer in humans; has produced tumors of the lungs, liver, thyroid, and adrenal glands in animals	Aldrin/dieldrin no longer produced in U.S.; prevent skin contact
Skin and nervous system effects	None

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on the testimony was presented. NIOSH recommendations were originally
as noted.

Potential Hazard and Source for NIOSH Recommendation*	OSHA PEL/Standard	REL ^t /Other Recommendations
		All are ceiling values (15 min) for individual alkanes or mixtures of alkanes: pentane, 610 ppm (1,800 mg/m ³); hexane, 510 ppm (1,800 mg/m ³); heptane, 440 ppm (1,800 mg/m ³); octane, 385 ppm (1,800 mg/m ³); action level set at 200 mg/m ³ for these substances
Allyl chloride (September 1976)	1 ppm (3 mg/m ³), 8-hr TWA	1 ppm (3.1 mg/m ³) TWA; 3 ppm (9.3 mg/m ³) ceiling (15 min)
4-Aminodiphenyl (NIOSH testimony at OSHA hearing September 1973)	No PEL; cancer-suspect agent; stringent workplace controls, recordkeeping, and medical monitoring required; 29 CFR 1910.1011	Ca; use 29 CFR 1910.1011
Ammonia (July 1974)	50 ppm (36 mg/m ³), 8-hr TWA	50 ppm (34.8 mg/m ³) ceiling (5 min)
Anesthetic gases (see Waste anesthetic gases)		
Animal rendering processes (Occupational Hazard Assessment March 1981)	OSHA PELs for specific hazards are applicable	NIOSH RELs for specific hazards are applicable

NIOSH

Health Effect(s) Considered*	Comments
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Liver, kidney, and lung effects Urine, blood, and pulmonary function testing required

Bladder cancer None

Respiratory and eye irritation Prevent eye contact

Mechanical injuries, burns, heat stress, infections from biologic agents, chemical hazards Guidelines have been presented for engineering controls and work practices to reduce injury and illness

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Antimony (September 1978)	0.5 mg/m ³ , 8-hr TWA	0.5 mg/m ³ TWA
Arsenic, inorganic (September 1974; revised June 1975; reaffirmed July 1982 as part of NIOSH testimony at OSHA hearing)	10 µg As/m ³ , 8-hr TWA; 29 CFR 1910.1018	Ce; 2 µg As/m ³ ceiling (15 min)
Arsine (CIB, August 1979)	0.2 mg/m ³ (0.05 ppm), 8-hr TWA	Ce; 2 µg/m ³ (0.002 mg/m ³) ceiling (15 min) (see arsenic criteria document)
Asbestos (January 1972; revised December 1976; revised March 1984 as part of NIOSH testimony at Congressional hearing; reaffirmed June 1984 as NIOSH testimony at OSHA hearing)	200,000 fibers/m ³ (fibers >5 µm long), 8-hr TWA; action level of 100,000 fibers/m ³ , 8-hr TWA; 29 CFR 1910.1001	Ce; 100,000 fibers/m ³ (fibers >5µm long), 8-hr TWA in a 400-liter air sample
Asphalt fumes (September 1977)	None	5 mg/m ³ ceiling (15 min) measured as total particu-
Benzene (July 1974; revised August 1976; revised July 1977 as part of NIOSH testimony at OSHA hearing; revised March 1986 as part of NIOSH testimony at OSHA hearing)	1 ppm, 8-hr TWA; 5 ppm short-term exposure limit (15 min)	Ce; 0.1 ppm (0.32 mg/m ³), 8-hr TWA; 1 ppm (3.2 mg/m ³) ceiling (15 min)

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[†]NIOSH TWA recommendations are based on exposures up to 10 hours unless otherwise noted.

[‡]Health effects cited are for humans unless otherwise noted.

Irritation, cardiovascular and lung effects	Periodic chest X-ray, pulmonary function testing, and electro- cardiogram required
Lung and lymphatic cancer, dermatitis	Periodic chest X-ray required
Sudden extensive hemolysis, cancer	Warn workers about working with arsenic compounds in presence of freshly formed hydrogen
Lung cancer, mesothelioma, asbestosis	Periodic chest X-ray and pulmonary function testing required
Eye and respiratory irritation	Medical monitoring required; prevent skin contact
Cancer (leukemia)	Prevent skin contact

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d or when the testimony was presented. NIOSH recommendations were originally
otherwise noted.

Potential Hazard and Source for NIOSH Recommendation*	OSHA PEL/Standard	REL [†] /Other Recommendations
Benzidine (NIOSH testimony at OSHA hearing, September 1973)	No PEL; cancer-suspect agent; stringent workplace controls, recordkeeping, and medical monitoring required; 29 CFR 1910.1010	Ca; use 29 CFR 1910.1010
Benzidine-based dyes (Special Hazard Review, January 1980; revised in "Preventing Health Hazards from... Benzidine Congener Dyes," January 1983)	No PEL for benzidine-based dyes	Ca; reduce exposure to lowest feasible concentration; replace with less toxic materials
Benzoyl peroxide (June 1977)	5 mg/m ³ , 8-hr TWA	5 mg/m ³ TWA
Benzyl chloride (August 1978)	5 mg/m ³ (1 ppm), 8-hr TWA	5 mg/m ³ ceiling (15 min)
Beryllium (June 1972; revised August 1977 as part of NIOSH testimony at OSHA hearing)	2 µg/m ³ , 8-hr TWA; 5 µg/m ³ acceptable ceiling; 25 µg/m ³ maximum ceiling (30 min)	Ca; do not exceed 0.5 µg Be/m ³
Boron trifluoride (December 1976)	1 ppm (3 mg/m ³) ceiling	No exposure limit recommended because of the absence of a reliable monitoring method; use appropriate engineering and work-practice controls to reduce exposure to lowest feasible concentration
1,3-Butadiene (CIB, February 1984)	1,000 ppm (2,200 mg/m ³), 8-hr TWA	Ca; reduce exposure to lowest feasible concentration

NIOSH**Health Effect(s)
Considered¹****Comments**

Bladder, liver, and kidney cancer	None
Bladder cancer	Stringent workplace controls and medical monitoring required; urine monitoring for benzidine suggested
Respiratory and eye irritation, skin effects	None
Irritation, skin and eye effects	Periodic chest X-ray and pulmonary function testing required
Lung cancer, berylliosis	Periodic chest X-ray and pulmonary function testing required
Respiratory effects	Pulmonary function testing required
Hematopoietic cancer, teratogenicity, reproductive system effects	Use appropriate engineering and work-practice controls; restrict access to areas where 1,3-butadiene is used

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Cadmium (August 1976; revised in CIB, September 1984)	Fume: 0.1 mg/m ³ , 8-hr TWA; 0.3 mg/m ³ ceiling Dust: 0.2 mg/m ³ , 8-hr TWA; 0.6 mg/m ³ ceiling	Ca; reduce exposure to lowest feasible concentration
Carbaryl (September 1976)	5 mg/m ³ , 8-hr TWA	5 mg/m ³ TWA
Carbon black (September 1978)	3.5 mg/m ³ , 8-hr TWA	3.5 mg/m ³ TWA; in presence of polycyclic aromatic hydrocarbons; Ca; 0.1 mg/m ³ TWA
Carbon dioxide (August 1976)	5,000 ppm (9,000 mg/m ³), 8-hr TWA	10,000 ppm (18,000 mg/m ³) TWA; 30,000 ppm (54,000 mg/m ³) ceiling (10 min)
Carbon disulfide (May 1977)	20 ppm, 8-hr TWA; 30 ppm acceptable ceiling; 100 ppm maximum ceiling (30 min)	1 ppm (3 mg/m ³) TWA; 10 (30 mg/m ³) ceiling (15 min)
Carbon monoxide (August 1972; Alert, August 1984)	50 ppm (55 mg/m ³), 8-hr TWA	35 ppm (40 mg/m ³), 8-hr TWA; 200 ppm (229 mg/m ³) ceiling (no defined time)
Carbon tetrachloride (December 1975; revised June 1976)	10 ppm, 8-hr TWA; 25 ppm acceptable ceiling; 200 ppm maximum ceiling (5 min in 4 hr)	Ca; 2 ppm (12.6 mg/m ³) ceiling (45-liter, 60-min sample)
Chlorine (May 1976)	1 ppm (3 mg/m ³) ceiling	0.5 ppm (1.45 mg/m ³) ceiling (15 min)

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west	Lung cancer, prostatic cancer, renal system effects	None
	Central nervous system and reproductive system effects	Warn workers of possible effects on reproductive system and permit only minimum exposure during pregnancy; prevent skin and eye contact
clic is:	Lung, cardiovascular, and skin effects; cancer of the lymphatic/bone-marrow complex when exposed to carbon black in the presence of polycyclic aromatic hydrocarbons	Periodic chest X-ray, pulmonary function testing, and ECG required
g/m ³)	Respiratory effects	None
g (10 min)	Cardiovascular, central nervous system, and reproductive system effects	Advise workers of potential effects on reproductive system
A; 10 ppm 5 min)	Cardiovascular effects	None
1-hr TWA; ceiling	Liver cancer	REL based on lowest limit of detection at time of document publication
elling (ole)	Eye and respiratory irritation	Periodic chest X-ray required

or when the testimony was presented. NIOSH recommendations were originally otherwise noted.

Potential Hazard and Source for NIOSH Recommendation*	OSHA PEL/Standard	REL [†] /Other Recommendations
Chloroethane (CIB, August 1978)	1,000 ppm (2,600 mg/m ³), 8-hr TWA	Handle with caution in the workplace
Chloroform (September 1974; revised June 1976)	50 ppm (240 mg/m ³) ceiling	Ca; 2 ppm (9.78 mg/m ³) ceiling (45 liter, 60 min sample)
bis-Chloromethyl ether (NIOSH testimony at OSHA hearing September 1973)	No PEL; cancer-suspect agent; stringent workplace controls, recordkeeping, and medical monitoring required; 29 CFR 1910.1008	Ca; use 29 CFR 1910.1008
Chloroprene (August 1977)	26 ppm (90 mg/m ³), 8-hr TWA	Ca; 1 ppm (3.6 mg/m ³) ceiling (15 min)
Chromic acid (July 1973; revised—see Chromium(VI), December 1975)	1 mg/10 m ³ (100 µg/m ³) ceiling	25 µg/m ³ (0.025 mg/m ³) TWA; 50 µg/m ³ (0.05 mg/m ³) ceiling (15 min) as noncarcinogenic Cr(VI)
Chromium(VI) (December 1975)	1 mg/10 m ³ (100 µg/m ³) ceiling	Ca; carcinogenic Cr(VI), 1 µg/m ³ TWA; other Cr(VI), 25 µg/m ³ TWA, 50 µg/m ³ ceiling (15 min)
Chrysene (Special Hazard Review, June 1978)	0.2 mg/m ³ , 8-hr TWA	Ca; control as an occupational carcinogen

NIOSH

Health Effect(s) Considered ^b	Comments
Central nervous system effects, possible liver and/or kidney effects	Exposures should be minimized because of structural similarity to carcinogenic chloroethanes
Potential for cancer in humans; has produced cancer of the liver and kidneys in animals; central nervous system effects	None
Lung cancer	None
Lung and skin cancer, reproductive effects	Periodic chest X-ray and pulmonary function testing required; counsel pregnant workers about continuing work with chloroprene
/A: Nasal ulceration	None
Lung cancer, skin ulcers, and lung irritation	Employer must demonstrate absence of carcinogenic Cr(VI); periodic chest X-ray required
Liver and skin cancer	Document also contains control recommendations for polycyclic aromatic hydrocarbons

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Coal gasification plants (September 1978)	OSHA PELs for specific hazards are applicable	NIOSH RELs for specific hazards are applicable
Coal liquefaction, (Occupational Hazard Assessment, 2 volumes, March 1981)	OSHA PELs for specific hazards are applicable	NIOSH RELs for specific hazards are applicable
Coal tar products (September 1977)	0.2 mg/m ³ , 8-hr TWA (benzene-soluble fraction); 29 CFR 1910.1002 (coal tar pitch volatiles)	Ca; 0.1 mg/m ³ TWA (cyclohexane extractable fraction)
Cobalt (Occupational Hazard Assessment, October 1981)	0.1 mg/m ³ , 8-hr TWA	NIOSH has concluded that there is insufficient evidence to warrant recommending an exposure limit
Coke oven emissions (February 1973; revised November 1975 as part of NIOSH testimony at OSHA hearing)	150 µg/m ³ , 8-hr TWA; 29 CFR 1910.1029	Ca; 0.5-0.7 mg/m ³ (500-700 µg/m ³) (total particulates) as screening level
Confined spaces, working in (December 1979)	Covered under numerous OSHA regulations for general industry (29 CFR 1910)	Various recommendations, including a permit system to prevent worker injury and
Cotton dust (September 1974; reaffirmed September 1983 as part of NIOSH testimony at OSHA hearing)	Lint-free respirable cotton dust in yarn manufacturing and cotton washing operations, 200 µg/m ³ , 8-hr TWA; lint-free respirable cotton dust in textile mill waste house operations or (continued on next page)	200 µg/m ³ lint-free cotton dust

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¹NIOSH TWA recommendations are based on exposures up to 10 hours unless otherwise noted.

²Health effects cited are for humans unless otherwise noted.

	Various effects depending on substances present; skin cancer	Extensive work-practice and control procedures recommended.
	Various effects depending on substances present; skin cancer	Extensive work-practice and control procedures recommended.
	Lung and skin cancer	Includes coal tar, creosote, and coal tar pitch; pulmonary function testing and periodic chest X-ray required
that com- limit 0 µg/m ³)	Dermatitis, potential for pulmonary fibrosis	Includes recommendations for engineering controls, work practices, protective equipment, worker education, and environmental and medical monitoring
	Lung cancer, bladder cancer	Periodic chest X-ray required; use work practices to minimize exposure to emissions
tions, stem to and death tion	Injury and death	Check for oxygen-deficient atmospheres and toxic gases before entry
	Pulmonary disease (byssinosis)	Pulmonary function testing required

or when the testimony was presented. NIOSH recommendations were originally otherwise noted.

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Potential Hazard and Source for NIOSH Recommendation*	OSHA PEL/Standard	REL [†] /Other Recommendations
lower-grade washed cotton in yarn manufacturing, 500 µg/m ³ ; 8-hr TWA; lint-free respirable cotton dust in slashing and weaving processes, 750 mg/m ³ ; 29 CFR 1910.1043	Cotton waste processing operations of waste recycling (sorting, blending, cleaning, and willowing) and garnetting, 1 mg/m ³ ; 29 CFR 1910.1000	2.3 ppm (10 mg/m ³) TWA
Creosol (February 1978)	5 ppm (22 mg/m ³). 8-hr TWA (Skin)	
DDT (Special Hazard Review, September 1978)	1 mg/m ³ , 8-hr TWA (Skin)	Ca; lowest reliably detectable concentration (currently 0.5 mg/m ³ TWA by NIOSH validated method)
2,4-Diaminoanisole and its salts (CIB, January 1978)	None	Ca; reduce exposure to low feasible concentration
o-Dianisidine-based dyes (joint NIOSH/OSHA health hazard alert, December 1980)	None	Ca; handle with caution in workplace and minimize exposures

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**Health Effect(s)
Considered³****Comments**

3) TWA	Skin, liver, kidney, and pancreas effects	Applies to mixtures of cresols and crorylic acid; prevent skin and eye contact; possible delayed effects
actable rently y NIOSH-	Potential for cancer in humans; has produced tumors of the liver, lungs, and lymphatic system in animals	Prevent skin contact
o lowest tion	Potential for cancer in humans; has produced tumors of the thyroid, skin, and lymphatic system in animals	Prevent skin contact; engineering and work-practice controls are recommended
on in the imize	Potential for cancer in humans; has produced tumors of the bladder, stomach, and mammary glands in animals	Substitute less toxic dyes wherever possible

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Dibromochloropropane (January 1978)	1 ppb, 8-hr TWA; 29 CFR 1910.1044	10 ppb (0.1 mg/m ³) TWA (NIOSH recommendation superseded by OSHA standard promulgated in 1978)
3,3'-Dichlorobenzidine (NIOSH testimony at OSHA hearing, September 1973)	No PEL; cancer-suspect agent; stringent workplace controls, recordkeeping, and medical monitoring required; 29 CFR 1910.1007	Ca; use 29 CFR 1910.1007
1,1-Dichloroethane (CIB, August 1978)	100 ppm (400 mg/m ³), 8-hr TWA	Handle with caution in the workplace
Dieldrin (see Aldrin/dieldrin)		
Diesel exhaust (CIB, July 1988)	OSHA and MSHA PELs for individual components of diesel exhaust are applicable	Ca; reduce exposure to lowest feasible concentration
Di-2-ethylhexyl phthalate (DEHP) (Special Hazard Review, March 1983)	5 mg/m ³ , 8-hr TWA	Ca; reduce exposure to lowest feasible concentration
Diacocyanates (September 1978)	Toluene diisocyanate (TDI), 0.02 ppm (0.14 mg/m ³) ceiling; diphenylmethane diisocyanate (MDI), 0.02 ppm (0.2 mg/m ³) ceiling	All values are in µg/m ³ and all ceilings are 10 min (each value is equivalent to 5 ppb TWA and 20 ppb ceiling); TDI, 35 TWA, 140 ceiling; MDI, 50 TWA, 200 ceiling; hexamethylene diisocyanate (continued on next page)

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[†]NIOSH TWA recommendations are based on exposures up to 10 hours unless otherwise specified.

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	Sterility, renal and liver effects	Regulated by OSHA as a carcinogen
Potential for cancer in humans; has produced tumors of the liver, bladder, and lungs in animals	None	
Central nervous system effects, possible liver and/or kidney damage	Exposures should be minimized because of structural similarity to carcinogenic chloroethanes	
Lung cancer, respiratory system effects, eye irritation	Typical components of diesel exhaust include carbon dioxide, carbon monoxide, formaldehyde, nitrogen dioxide, nitric oxide, sulfur dioxide, respirable dust, and polynuclear aromatic hydrocarbons	MWNR
Potential for cancer in humans; has produced liver tumors in animals	DEHP (widely used in the quantitative fit testing of respirators) should be replaced with less toxic material such as refined corn oil	
Respiratory effects and sensitization, pulmonary irritation	Periodic chest X-ray and pulmonary function testing required	

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or when the testimony was presented. NIOSH recommendations were originally otherwise noted.

Potential Hazard and Source for NIOSH Recommendation*	OSHA PEL/Standard	REL ^b /Other Recommendations
4-Dimethylaminoazobenzene (NIOSH testimony at OSHA hearing, September 1973)	No PEL; cancer-suspect agent; stringent workplace controls, recordkeeping, and medical monitoring required; 29 CFR 1910.1015	(HDI), 35 TWA, 140 ceiling; naphthalene diisocyanate (NDI), 40 TWA, 170 ceiling; isophorone diisocyanate (IPDI), 45 TWA, 180 ceiling; dicyclohexylmethane 4,4'-diisocyanate (hydrogenated MDI), 55 TWA, 210 ceiling. Control other diisocyanates to 20 ppb ceiling and 5 ppb TWA
Dinitro-ortho-cresol (February 1978)	0.2 mg/m ³ , 8-hr TWA (Skin)	Ce; use 29 CFR 1910.1015
Dinitrotoluenes (CIB, July 1985)	1.5 mg/m ³ , 8-hr TWA (Skin)	Ce; reduce exposure to lowest feasible concentration
Dioxane (September 1977)	100 ppm (360 mg/m ³), 8-hr TWA (Skin)	Ce; 1 ppm (3.6 mg/m ³) ceiling (30 min)
Dioxin (see 2,3,7,8-Tetrachlorodibenzo-p-dioxin)		

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Health Effect(s) Considered ^b	Comments
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Potential for cancer in humans; has produced tumors of the liver and bladder in animals

None

Central nervous system and metabolic effects

Blood and urine monitoring required; prevent skin and eye contact; possible delayed effects

Potential for cancer in humans; has produced tumors of the liver, skin, and kidneys in animals; reproductive system effects

Prevent skin contact

Potential for cancer in humans; has produced tumors of liver, lungs, and nasal cavity in animals; effects on liver and kidney

Blood and urine testing required; prevent skin contact

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Electrical energy and electrocutions (Alerts, December 1984, July 1985, July 1986, October 1986, December 1986; revised in written comments to OSHA, February 1988)	Electrical protective devices, 29 CFR 1910.137; design safety standards for electrical systems, 29 CFR 1910.302-.330; safety-related work practices, 29 CFR 1910.331-.360; safety related maintenance, 29 CFR 1910.361-.380; safety requirements for special equipment, 29 CFR 1910.381-.398	Numerous work practice control recommendations reducing the risk of electrocutions and related injuries
Elevated workstations, emergency egress from (December 1975)	Sections under Subpart E, Means of Egress, General Industry Standards, and Subpart R, Special Industries (29 CFR 1910.261)	Various recommendations concerning means and availability of egress
Epichlorohydrin (September 1976; revised in CIB October 1978)	5 ppm (19 mg/m ³), 8-hr TWA	Ca; minimize occupational exposure
2-Ethoxyethanol (see Glycol ethers)		
Ethyl chloride (see Chloroethane)		
Ethylene dibromide (August 1977; revised November 1983; reaffirmed February 1984 as part of NIOSH testimony at OSHA hearing)	20 ppm, 8-hr TWA; 30 ppm acceptable ceiling; 50 ppm maximum peak (5 min)	Ca; 0.045 ppm (0.38 mg/m ³) 8-hr TWA; 0.13 ppm (1 mg/m ³) ceiling (15 min)

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[‡]Health effects cited are for humans unless otherwise noted.

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Injury and death

Prompt emergency medical care can be lifesaving for workers who have contacted electrical energy; immediate cardiopulmonary resuscitation followed by advanced cardiac life support has been shown to save lives

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ditions
and
es

Trauma and injury

None

onal

Respiratory cancer;
mutagenesis; reproductive,
skin, kidney, liver,
and respiratory effects

Prevent skin contact.

MMWR

g/m³),
m

Potential for cancer in
humans; mutagenesis;
damage to skin, eyes,
heart, liver, spleen, and
reproductive, respiratory,
and central nervous systems

Warn workers of potential for
reproductive abnormalities and
cancer; hazardous liquid;
prevent skin contact

ed or when the testimony was presented. NIOSH recommendations were originally
as otherwise noted.

Potential Hazard and Source for NIOSH Recommendation*	OSHA PEL/Standard	REL [†] /Other Recommendations
Ethylene dichloride (March 1976; revised in CIB April 1978; revised September 1978)	50 ppm, 8-hr TWA; 100 ppm acceptable ceiling; 200 ppm maximum ceiling (5 min in 3 hr)	Ca; 1 ppm (4 mg/m ³) TWA; 2 ppm (8 mg/m ³) ceiling (15 min)
Ethylenimine (NIOSH testimony at OSHA hearing, September 1973)	0.5 ppm (1 mg/m ³), 8-hr TWA (Skin); 29 CFR 1910.1012	Ca; use 29 CFR 1910.1012
Ethylene oxide (Special Hazard Review, September 1977; revised July 1983 as part of NIOSH testimony at OSHA hearing)	1 ppm (1.8 mg/m ³), 8-hr TWA; 5 ppm excursion limit (15 min); 29 CFR 1910.1047	Ca; 5 ppm (9 mg/m ³) ceiling (10 min/day); <0.1 ppm (0.18 mg/m ³), 8-hr TWA
Ethylene thiourea (Special Hazard Review, October 1978)	None	Ca; use in encapsulated form in industry; minimize worker exposure
Excavations, development of draft construction safety standards for (Technical Guideline, May 1983)	Many aspects covered under OSHA regulations governing excavations, trenching, and shoring practices in the construction industry (29 CFR 1926, Subpart P)	Many work-practice recommendations concerning safety standards for excavations
Fibrous glass (April 1977)	Nuisance dust PEL applies: 15 mg/m ³ total dust; 5 mg/m ³ respirable fraction	3 million fibers/m ³ TWA (fibers <3.5 µm in diameter and ≥10 µm long); 5 mg/m ³ TWA (total fibrous glass)
Fluorides, inorganic (June 1975)	2.5 mg F/m ³ , 8-hr TWA	2.5 mg F/m ³ TWA

NIOSH

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Health Effect(s) Considered¹	Comments
Potential for cancer in humans; nervous system, respiratory, cardiovascular, and liver effects	Nursing infants of exposed mothers are at risk
Potential for cancer in humans; has produced tumors of the liver and lung in animals	Stringent workplace controls and medical monitoring required
Peritoneal cancer, leukemia, mutagenesis, reproductive effects	Blood monitoring and medical counseling recommended
Potential for cancer and teratogenicity in humans; has produced tumors of the liver, thyroid, and lymphatic system in animals	Inform workers of carcinogenic and teratogenic hazards; give special attention to thyroid function tests
Injury and death	Follow appropriate work-practice guidelines and provide shoring
Eye, skin, and respiratory effects	NIOSH recommends that this REL also apply to other manmade fibers
Kidney and bone effects	Urine monitoring required

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Fluorocarbon polymers, decomposition products of (September 1977)	None	Various recommendations emphasizing good work practices, engineering controls, and medical management
Formaldehyde (December 1976; revised in CIB, April 1981; revised May 1986 as part of NIOSH testimony at OSHA hearing; revised February 1987 in written comments to OSHA)	1 ppm, 8-hr TWA; 2 ppm short-term exposure limit (15 min); 29 CFR 1910.1048	Ca; 0.016 ppm, 8-hr TWA; 0.1 ppm ceiling (15 min) (this limit represents the lowest reliably quantifiable concentration)
Foundries (September 1985)	Many aspects covered under the numerous OSHA regulations for general industry (29 CFR 1910)	Various recommendations emphasizing good work practices, engineering controls, and medical monitoring
Furfuryl alcohol (March 1979)	50 ppm (200 mg/m ³), 8-hr TWA	50 ppm (200 mg/m ³) TWA
Gallium arsenide (Alert, October 1987)	10 µg As/m ³ , 8-hr TWA; 29 CFR 1910.1018	Ca; 2 µg As/m ³ ceiling (15 min); see arsenic CD
Glycidyl ethers (June 1978; revised in CIB, October 1978)	All values in ppm (mg/m ³): allyl glycidyl ether (AGE), 10 (45) ceiling; n-butyl glycidyl ether (BGE), 50 (270), 8-hr TWA; di-2,3-epoxypropyl ether (DGE), 0.5 (2.8) ceiling; (continued on next page)	All are ceiling values (15 min) in ppm (mg/m ³): AGE, 9.6 (45); BGE, 5.6 (30); DGE, 0.2 (1) Ce; IGE, 50 (240); PGE, 1 (5)

*Dates in parentheses indicate when the NIOSH recommendation was published or when published in criteria documents unless otherwise noted.

[†]NIOSH TWA recommendations are based on exposures up to 10 hours unless otherwise specified.

[‡]Health effects cited are for humans unless otherwise noted.

Lung effects; polymer fume fever	Monitor workroom air for inorganic fluorides and hydrogen fluoride
Nasal cancer	Implement medical monitoring; protect skin
Cancer, respiratory disease, heat-induced illness, noise-induced hearing loss, vibration-induced disorders, eye injuries, traumatic and ergonomic injuries	Recommendations limited to foundries that pour molten metal into sand molds
Respiratory effects	None
Cancer	Gallium arsenide may dissociate in the body, releasing gallium and inorganic arsenic
DGE: Potential for cancer in humans; has produced skin tumors in animals. DGE and other glycidyl ethers: skin and mucous membrane effects, sensitization potential, possible hematopoietic and reproductive system effects	Possible additive effects with mixtures; medical monitoring

when the testimony was presented. NIOSH recommendations were originally
vise noted.

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Potential Hazard and Source for NIOSH Recommendation*

OSHA PEL/Standard

REL[†]/Other Recommendations

isopropyl glycidyl ether (IGE),
50 (240), 8-hr TWA;
phenyl glycidyl ether (PGE),
10 (60), 8-hr TWA

Glycol ethers
(CIB, May 1983)

2-Methoxyethanol, 25 ppm
(80 mg/m³), 8-hr TWA (Skin);
2-ethoxyethanol, 200 ppm
(740 mg/m³), 8-hr TWA (Skin)

Grain dust
(Technical Guide-line, September 1983; reaffirmed June 1984 as part of NIOSH testimony at OSHA hearing; revised in Arbete Och Halsa, 1988:14 [in press])

Many general aspects (e.g., protective equipment, dust control, etc.) covered under the numerous OSHA regulations for general industry and grain-handling facilities (29 CFR 1910 and 1917); final rule published in Federal Register 52 (251): 49592-49631, Dec. 31, 1987

Hexachloroethane
(CIB, August 1978)

1 ppm (10 mg/m³), 8-hr TWA (Skin)

Hot environments
(June 1972; revised April 1986)

None

Hydrazines
(June 1978)

All values in ppm (mg/m³):
hydrazine, 1 (1.3),
8-hr TWA (Skin);
1,1-dimethylhydrazine, 0.5 (1.0), 8-hr TWA (Skin);
phenylhydrazine, 5 (22),
8-hr TWA (Skin);
methylhydrazine, 0.2 (0.35)
ceiling

Reduce exposure to low feasible concentration

Various recommendations control of combustible dust and ignition sources, machine guarding, isolation and setbacks, bin entry, training, personal protective equipment, settled grain dust not to exceed ¼ of an inch to reduce risk of explosion

Ca;
reduce exposure to low feasible concentration

Sliding scale limits based on environmental and metabolic heat loads

Ca;
all are ceiling values (120 min) in ppm (mg/m³):
hydrazine, 0.03 (0.04);
1,1-dimethylhydrazine, (0.15);
phenylhydrazine, 0.14 (0.15);
methylhydrazine, 0.04 (0.05)

NIOSH

	Health Effect(s) Considered ⁸	Comments
o lowest ion	Male and female reproductive effects, teratogenicity	Prevent skin contact
ditions for ible dusts es, machine and lock- ining, and equipment; not inch explosion	Injury and death, chronic bronchitis, asthma, and chronic obstructive pulmonary disease	Health hazards from exposure to fumigants, pesticides, and grain dust; safety hazards from confined spaces and explosions; reducing exposure to grain dust will decrease exposure to agents that elicit adverse health effects
o lowest ion	Potential for cancer in humans; has produced liver tumors in animals	Prevent skin contact
based and ds	Heat-induced illnesses	Recommendations include acclimatization, strict work practices, protective equipment, and medical monitoring
es mg/m ³): 04); zine, 0.06 0.14 (0.6); 0.04 (0.08)	Potential for cancer in humans; has produced tumors of the lung, liver, blood vessels, and intestines in animals; blood, liver, and skin effects	Blood and urine monitoring and periodic chest X-ray required; bowel examination for workers above age 40

Hydrogen cyanide and cyanide salts (October 1976)	Hydrogen cyanide, 10 ppm (11 mg/m ³), 8-hr TWA (Skin); cyanide, 5 mg CN/m ³ , 8-hr TWA (Skin)	4.7 ppm CN (5 mg CN/m ³) ceiling (10 min)
Hydrogen fluoride (March 1976)	3 ppm, 8-hr TWA	2.5 mg F/m ³ (3 ppm) TWA 5.0 mg F/m ³ (6 ppm) ceiling (15 min)
Hydrogen sulfide (May 1977)	20 ppm acceptable ceiling; 50 ppm maximum ceiling (10 min)	10 ppm (15 mg/m ³) ceiling (10 min)
Hydroquinone (April 1978)	2 mg/m ³ , 8-hr TWA	0.44 ppm (2 mg/m ³) ceiling (15 min)
Identification system for occupationally hazardous materials (December 1974)	Sections of Hazard Communication (29 CFR 1910.1200) and carcinogen standards may be applicable	Complete designation applies for occupationally hazardous materials
Isopropyl alcohol (March 1976)	400 ppm (984 mg/m ³), 8-hr TWA	400 ppm (984 mg/m ³) TWA 800 ppm (1,968 mg/m ³) ceiling (15 min)
Kepone (January 1976)	None	Ca; 1 µg/m ³ TWA
Ketones (June 1978)	All are 8-hr TWA values in ppm (mg/m ³): acetone, 1,000 (2,400); methyl ethyl ketone, 200 (590); methyl n-propyl ketone, 200 (700) methyl n-butyl ketone, 100 (410); (continued on next page)	All are TWA values in ppm (mg/m ³): acetone, 250 (600); methyl ethyl ketone, 200 (590); methyl n-propyl ketone, 200 (530); methyl n-butyl ketone, 100 (410); methyl isobutyl ketone, 100 (465); methyl isobutyl ketone, 100 (465); (continued on next page)

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[†]NIOSH TWA recommendations are based on exposures up to 10 hours unless otherwise noted.

[‡]Health effects cited are for humans unless otherwise noted.

CN/m ³)	Thyroid, blood, and respiratory system effects	Concurrent measurement required for HCN when measuring for cyanide salt; make available trained first-aid personnel and first-aid kits during use; prevent skin and eye contact
(n) TWA; (n) ceiling	Skin, eye, and airway irritation; bone effects	Periodic pelvic X-ray to detect changes in the osseous system (male workers only) and urine testing required
ceiling	Irritation, severe acute effects involving nervous and respiratory systems	Continuous monitoring required if potential exists for exposure to $\geq 70 \text{ mg/m}^3$ (47 ppm); evacuation required at this level
(n) ceiling	Eye and skin effects	Special provisions for darkroom use
ion system hazardous	None	Includes definition, safety data sheets, alert symbols, and label statements
(n ³) TWA; g/m ³)	Mucous membrane irritation, possible cancer threat in manufacturing process	Stringent work practices and medical monitoring for manufacturing workers required
in ppm 250 (590); e, 200 (590); tone, 150 ethyl ketone, ethyl ketone, sobutyl page)	Liver cancer, nervous system effects	Liver function testing required
	Irritation; liver, kidney, and nervous system effects	Urinalysis required; warn exposed workers about nervous system effects of methyl n-butyl ketone

ed or when the testimony was presented. NIOSH recommendations were originally otherwise noted.

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Potential Hazard and Source for NIOSH Recommendation*	OSHA PEL/Standard	REL [†] /Other Recommendations
	methyl n-amyl ketone, 100 (465); methyl isobutyl ketone, 100 (410); methyl isoamyl ketone, none; diisobutyl ketone, 50 (290); cyclohexanone, 50 (200); mesityl oxide, 25 (100); diacetone alcohol, 50 (240); isophorone, 25 (140)	ketone, 50 (200); methyl isoamyl ketone, 50 (230); diisobutyl ketone, 25 (140); cyclohexanone, 25 (100); mesityl oxide, 10 (40); diacetone alcohol, 50 (240); isophorone, 4 (23)
Land-based oil and gas well drilling, comprehensive safety recommendations for (Technical Guideline, September 1983; reaffirmed March 1984 as part of NIOSH testimony at OSHA hearing)	Many aspects covered under the numerous OSHA regulations for general industry (29 CFR 1910)	Various recommendations for safe work practices and technologic improvements
Lead, inorganic (January 1973; revised May 1978)	50 µg Pb/m ³ , 8-hr TWA; determine by formula for exposures >8 hr; 29 CFR 1910.1025	<100 µg Pb/m ³ TWA; air levels to be maintained so that whole blood lead remains <60 µg/100 g of whole blood
Lockout/tagout, guidelines for controlling hazardous energy during maintenance and servicing (Technical Guideline, September 1983)	Many aspects covered under OSHA regulations for general industry (29 CFR 1910) and construction standards (29 CFR 1926)	Work-practice recommendations for controlling hazardous energy during maintenance servicing activities
Logging from felling to first haul (July 1976)	None	Extensive work-practice and personal protection recommendations
Malathion (June 1976)	15 mg/m ³ , 8-hr TWA (Skin)	15 mg/m ³ TWA

Health Effect(s) Considered*	Comments
Injury and death	Many tasks, types of equipment, and conditions not covered by existing regulations
Kidney, blood, and nervous system effects	Blood monitoring required
Injury and death	"Energy" is defined in this document as kinetic energy, potential energy, electrical energy, and thermal energy
Primarily trauma and falls	Institute tetanus toxoid inoculations and first-aid programs
Nervous system effects	Prevent skin contact; blood monitoring required

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Mechanical power presses, injuries and amputations resulting from (CIB, May 1987)	29 CFR 1910.217	Various recommendations for the safe use of mechanical power presses, specifically those operated by a dual palm-button control.
Mercury, inorganic (August 1973)	0.1 mg/m ³ acceptable ceiling	0.05 mg Hg/m ³ , 8-hour TWA
2-Methoxyethanol (see Glycol ethers)		
Methyl alcohol (March 1976)	200 ppm (260 mg/m ³), 8-hr TWA	200 ppm (262 mg/m ³), 800 ppm (1,048 mg/m ³), 15 min
Methyl chloromethyl ether (NIOSH testimony at OSHA hearing, September 1973)	No PEL; cancer-suspect agent; stringent workplace controls, recordkeeping, and medical monitoring required; 29 CFR 1910.1006	Ca; use 29 CFR 1910.1006
4,4'-Methylenebis (2-chloroaniline) (MOCA) (Special Hazard Review, September 1978)	Standard formally revoked by OSHA, August 1975	Ca; 3 µg/m ³ TWA (low detectable concentration)
Methylene chloride (March 1976; revised April 1986 in CIB)	500 ppm, 8-hr TWA; 1,000 ppm acceptable ceiling; 2,000 ppm acceptable maximum peak for 5 min in any 2-hr period above the acceptable ceiling for an 8-hr shift	Ca; reduce exposure to feasible concentrations
4,4'-Methylene-dianiline (CIB, July 1986)	None	Ca; reduce exposure to feasible concentrations

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*NIOSH TWA recommendations are based on exposures up to 10 hours unless otherwise noted.

*Health effects cited are for humans unless otherwise noted.

Recommendations for of mechanical s, specifically ed by foot or tton controls	Amputations and other injuries	Injuries and amputations among press operators occur with alarming frequency
2 mg/m ³) TWA; 48 mg/m ³) ceiling	Central nervous system and mental effects	Emphasize work practices, sanitation, and environmental and medical monitoring
910.1006	Blindness, metabolic acidosis	None
Lung cancer		None
A (lowest concentration)	Potential for cancer in humans; has produced liver and lung tumors in animals	Periodic chest X-ray; blood and urine testing required
sure to lowest concentration	Potential for cancer in humans; has produced tumors of the lung, liver, salivary, and mammary glands in animals	None
sure to lowest concentration	Bladder cancer, skin and liver effects	Prevent skin contact

published or when the testimony was presented. NIOSH recommendations were originally
unless otherwise noted.

Potential Hazard and Source for NIOSH Recommendation*	OSHA PEL/Standard	REL [†] /Other Recommendations
Methyl parathion (September 1976)	None	0.2 mg/m ³ TWA
Monohalomethanes (CIB, September 1984)	Methyl chloride: 100 ppm, 8-hr TWA; 200 ppm ceiling; 300 ppm acceptable maximum peak for 5 min in any 3-hr period above the acceptable ceiling for an 8-hr shift. Methyl bromide: 20 ppm (80 mg/m ³) ceiling (Skin). Methyl iodide: 5 ppm (28 mg/m ³), 8-hr TWA (Skin)	Ca; reduce exposures to methyl chloride, methyl bromide, and methyl iodide to the lowest feasible concentrations
alpha-Naphthylamine (NIOSH testimony at OSHA hearing, September 1973)	No PEL; cancer-suspect agent; stringent workplace controls, recordkeeping, and medical monitoring required; 29 CFR 1910.1004	Ca; use 29 CFR 1910.1004
beta-Naphthylamine (NIOSH testimony at OSHA hearing, September 1973)	No PEL; cancer-suspect agent; stringent workplace controls, recordkeeping, and medical monitoring required; 29 CFR 1910.1009	Ca; use 29 CFR 1910.1009
Niax® Catalyst ESN (joint NIOSH/OSHA CIB, May 1978)	Minimize exposure to Niax® Catalyst ESN and its components and dimethylamino-propionitrile and bis[2-(dimethylamino) ethyl] ether	Minimize exposure to Niax Catalyst ESN and its components, dimethylamino-propionitrile and bis[2-(dimethylamino) ethyl] ether
Nickel carbonyl (Special Hazard Review, May 1977)	1 ppb (7 µg/m ³), 8-hr TWA	Ca; 1 ppb (7 µg/m ³) TWA (lowest detectable concentration)

NIOSH

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Health Effect(s) Considered⁴	Comments
Central nervous system effects	Prevent skin contact; blood monitoring required
Potential for cancer in humans; has produced tumors of the kidney, forestomach, and lung in animals; methyl chloride should also be considered a potential teratogen	Prevent skin contact
Bladder cancer	None
Bladder cancer	None
Urological disorders, nervous system effects	Use work-practice and engineering controls to reduce exposure
Lung and nasal cancer	Periodic chest X-ray, pulmonary function testing, and urine monitoring required

MMR

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Nickel, inorganic compounds (May 1977)	1 mg Ni/m ³ , 8-hr TWA	Ca; 15 µg Ni/m ³ TWA
Nitric acid (March 1976)	2 ppm (5 mg/m ³), 8-hr TWA	2 ppm (5 mg/m ³) TWA
Nitriles (September 1978)	Acetonitrile, 40 ppm (70 mg/m ³), 8-hr TWA; tetramethyl succinonitrile, 0.5 ppm (3 mg/m ³), 8-hr TWA (Skin)	All are TWA values in ppm (mg/m ³): acetonitrile, 20 (34); n-butyronitrile, 8 (22); isobutyronitrile, 8 (22); propionitrile, 6 (14); malononitrile, 3 (8); adiponitrile, 4 (18); succinonitrile, 6 (20). All are ceiling values (15 min) in ppm (mg/m ³): acetone cyanohydrin, 1 (4); glycolonitrile, 2 (5); tetramethylsuccinonitrile, 1 (6). When present as mixtures or with other sources of cyanide, consider exposures additive and calculate environmental limit
4-Nitrobiphenyl (NIOSH testimony at OSHA hearing, September 1973)	No PEL; cancer-suspect agent; stringent workplace controls, recordkeeping, and medical monitoring required; 29 CFR 1910.1003	Ca; use 29 CFR 1910.1003
Nitrogen, oxides of (March 1976)	NO ₂ , 5 ppm (9 mg/m ³) ceiling; NO, 25 ppm (30 mg/m ³), 8-hr TWA	NO ₂ , 1 ppm (1.8 mg/m ³) ceiling (15 min); NO, 25 ppm (30 mg/m ³) TWA

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[†]NIOSH TWA recommendations are based on exposures up to 10 hours unless otherwise noted.

[‡]Health effects cited are for humans unless otherwise noted.

Lung and nasal cancer, skin effects	Periodic chest X-ray and pulmonary function testing required
Dental erosion, nasal/lung irritation	Prevent skin and eye contact; periodic chest X-ray required
Hepatic, renal, respiratory, cardiovascular, gastrointestinal, and nervous system effects	Periodic chest X-ray and pulmonary function testing required; make trained personnel and first-aid kits available during use; prevent skin and eye contact
Potential for cancer in humans; has produced bladder tumors in animals	None
Respiratory effects, blood effects	Pulmonary function testing required

hen the testimony was presented. NIOSH recommendations were originally
wise noted.

Potential Hazard and Source for NIOSH Recommendation*	OSHA PEL/Standard	REL [†] /Other Recommendations
Nitroglycerin and ethylene glycol dinitrate (EGDN) (June 1978)	Nitroglycerin, 2 mg/m ³ , (0.2 ppm) ceiling (Skin); EGDN, 1 mg/m ³ (0.2 ppm) ceiling (Skin)	0.1 mg/m ³ ceiling (20 min) recommended limit for either substance alone or mixtures
2-Nitronaphthalene (CIB, December 1976)	None	Ca; reduce exposure to lowest feasible concentration
2-Nitropropane (CIB, April 1977; revised October 1980 in joint OSHA/NIOSH Health Hazard Alert)	25 ppm (90 mg/m ³), 8-hr TWA	Ca; reduce exposure to lowest feasible concentration
N-Nitrosodimethylamine (NIOSH testimony at OSHA hearing, September 1973)	No PEL; cancer-suspect agent; stringent workplace controls, recordkeeping, and medical monitoring required; 29 CFR 1910.1016	Ca; use 29 CFR 1910.1016
Noise (August 1972)	90 dBA, 8-hr TWA	85 dBA TWA; 115 dBA ceiling
Organic solvents, (CIB, March 1987)	Numerous organic solvents covered under 29 CFR 1910.1000	RELs exist for approximately 92 chemicals and mixtures that may be defined as organic solvents; see entry for specific solvent of interest
Organotin compounds (November 1976)	0.1 mg/m ³ , 8-hr TWA	0.1 mg Sn/m ³ TWA

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Health Effect(s) Considered ³	Comments
Circulatory system effects	Prevent skin contact
Bladder cancer	Compound metabolizes to beta-naphthylamine, a known carcinogen
Potential for cancer in humans; has produced liver tumors in rats	Conduct medical monitoring with specific emphasis on liver function tests
Potential for cancer in humans; has produced tumors of the liver, kidney, lung, and nasal cavity in animals	None
Hearing damage	None
Neurotoxic effects including narcosis, anesthesia, CNS depression, respiratory arrest; impaired psychomotor function, manual dexterity, coordination, or body balance; peripheral neuropathy and toxic encephalopathy	None
Eye, skin, liver, nervous system, and heart effects	Periodic chest X-ray, blood and urine monitoring, eye tests, heart examination, and nervous system testing required; prevent skin and eye contact

MMWR

August 26, 1988

Paint and allied coating products, manufacture of (September 1984)	Many aspects covered under the numerous OSHA regulations for general industry (29 CFR 1910)	Various recommendations for the handling of raw materials and finished products, dispersion of pigment or resin particles, filling, laboratory functions, and thinning, tinting, and shading
Parathion (June 1976)	0.1 mg/m ³ , 8-hr TWA (Skin)	0.05 mg/m ³ TWA
Pentachloroethane (CIB, August 1978)	None	Handle with caution in the workplace
Pesticides, manufacture and formulation of (July 1978)		Follow current OSHA PELs or NIOSH RELs; institute stringent work-practice and medical monitoring requirements
Phenol (July 1976)	5 ppm (19 mg/m ³), 8-hr TWA (Skin)	5.2 ppm (20 mg/m ³) TWA; 15.6 ppm (60 mg/m ³) ceiling (15 min)
Phenyl-beta-naphthylamine (CIB, December 1976)	None	Ca; reduce exposure to lowest feasible concentration
Phosgene (February 1976)	0.1 ppm (0.4 mg/m ³), 8-hr TWA (Skin)	0.1 ppm (0.4 mg/m ³) TWA; 0.2 ppm (0.8 mg/m ³) ceiling (15 min)
Polychlorinated biphenyls (September 1977)	42% chlorine, 1 mg/m ³ , 8-hr TWA (Skin); 54% chlorine, 0.5 mg/m ³ , 8-hr TWA (Skin)	Ca; 1 µg/m ³ TWA (the minimum reliably detectable concentration using the recommended sampling and analytical methods)

*Dates in parentheses indicate when the NIOSH recommendation was published or will be published in criteria documents unless otherwise noted.

[†]NIOSH TWA recommendations are based on exposures up to 10 hours unless otherwise noted.

^{*}Health effects cited are for humans unless otherwise noted.

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ions for aterials dispers- in parti- func- ting,	Injury; a wide range of toxicities considered	Paint and allied coating products include paints, varnishes, lacquers, stains, putties, and paint and varnish removers
the	Nervous system effects	Prevent skin contact; blood monitoring required
ringent	Central nervous system effects, possible liver and kidney effects	Exposures should be minimized because of structural similarity to carcinogenic chloroethanes
WA;	Wide range of toxicities considered; cancer; nervous and reproductive system effects	Blood monitoring required for some groups; warn workers of reproductive effects for some compounds; prevent skin contact
west	Skin, eye, central nervous system, liver, and kidney effects	Prevent skin and eye contact
TWA; ceiling	Bladder cancer	Compound metabolizes to beta-naphthyleamine, a known carcinogen
imum	Respiratory effects	Pulmonary function testing and periodic chest X-ray required
ne ng and	Potential for cancer in humans; has produced tumors of the liver and pituitary gland and leukemias in animals; skin, liver, and reproductive system effects	Blood testing required; warn female workers of child-bearing age and nursing mothers of potential adverse effects; prevent skin contact

or when the testimony was presented. NIOSH recommendations were originally
otherwise noted.

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Potential Hazard and Source for NIOSH Recommendation*	OSHA PEL/Standard	REL [†] /Other Recommendations
Polychlorinated biphenyls from electrical equipment fires or failures (CIB, February 1986)	42% chlorine, 1 mg/m ³ , 8-hr TWA (Skin); 54% chlorine, 0.5 mg/m ³ , 8-hr TWA (Skin)	Ca; reduce exposure to lowest feasible concentration
Precast concrete products (Technical Guideline, June 1984)	Some aspects covered under the numerous OSHA regulations for general industry (29 CFR 1910)	Various recommendations for safe work practices and worker training
beta-Propiolactone (NIOSH testimony at OSHA hearing, September 1973)	No PEL; cancer-suspect agent; stringent workplace controls, recordkeeping, and medical monitoring required; 29 CFR 1910.1013	Ca; use 29 CFR 1910.1013
Radon progeny in underground mines (October 1987)	MSHA standard is 1.0 WL with annual cumulative exposure of 4.0 WLM; see 30 CFR 57.5037 through 30 CFR 57.5047	Ca; 1.0 WLM/year with average workshift concentration $\leq 1/12$ of 1.0 WL (or 0.083 WL)
Refined petroleum solvents (July 1977)	Petroleum distillates (naphtha), 2,000 mg/m ³ (500 ppm), 8-hr TWA; Standard solvent, 2,900 mg/m ³ (500 ppm), 8-hr TWA	Kerosene, 100 mg/m ³ TWA; all other solvents, 350 mg/m ³ TWA, 1,800 mg/m ³ ceiling (15 min)

Health Effect(s) Considered ¹	Comments
Potential for cancer in humans; has produced tumors of the liver and pituitary gland and leukemias in animals; skin, liver, and reproductive system effects	Fire-related incidents involving PCBs have resulted in widespread contamination of buildings with PCBs, and in some cases, with PCDFs and PCDDs, including TCDD. Emergency response personnel, maintenance or cleanup workers, or building occupants may be exposed to these compounds
Injury and death	Equipment, conditions, and many of the tasks specific to the industry are not covered under the existing regulations
Potential for cancer in humans; has produced tumors of the liver, skin, and stomach in animals	None
Lung cancer	REL of 1.0 WLM/year is upper limit of cumulative exposure, and every effort shall be made to reduce exposures to the lowest possible levels
Eye, nose, and throat irritation; dermatitis; nervous system effects	Blood and urine monitoring required; action level for petroleum ether, rubber solvent, naphtha is 200 mg/m ³ TWA; action level for mineral spirits and Stoddard solvent is 350 mg/m ³ TWA; action level for kerosene is 100 mg/m ³ TWA; prevent skin contact

Silica, crystalline (November 1974)	Respirable quartz, 250 mppcf or $\frac{10\text{mg/m}^3}{\% \text{SiO}_2 + 5}$ $\frac{\% \text{SiO}_2 + 5}{\% \text{SiO}_2 + 2}$	Respirable free silica, 50 $\mu\text{g/m}^3$ TWA
Sodium hydroxide (September 1975)	2 mg/ m^3 , 8-hr TWA	2 mg/ m^3 ceiling (15 min)
Styrene (September 1983)	100 ppm, 8-hr TWA; 200 ppm acceptable ceiling; 600 ppm maximum ceiling (5 min in 3 hr)	50 ppm (213 mg/ m^3) TWA; 100 ppm (426 mg/ m^3) ceiling (15 min)
Sulfur dioxide (February 1974; revised May 1977 as part of NIOSH testimony at OSHA hearing)	5 ppm (13 mg/ m^3), 8-hr TWA	0.5 ppm (1.3 mg/ m^3) TWA
Sulfuric acid (June 1974)	1 mg/ m^3 , 8-hr TWA	1 mg/ m^3 TWA
2,3,7,8-Tetrachloro- dibenzo-p-dioxin (TCDD) (CIB, January 1984)	None	Ca; reduce exposure to lowest feasible concentration
1,1,1,2-Tetrachloro- ethane (CIB, August 1978)	None	Handle with caution in the workplace
1,1,2,2-Tetrachloro- ethane (December 1976; revised in CIB, August 1978)	5 ppm (35 mg/ m^3), 8-hr TWA (Skin)	Ca; reduce exposure to lowest feasible concentration
Tetrachloroethylene (July 1976; revised January 1978 in CIB)	100 ppm, 8-hr TWA; 200 ppm acceptable ceiling; 300 ppm maximum ceiling (5 min in 3 hr)	Ca; minimize workplace exposure concentration

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[†]NIOSH TWA recommendations are based on exposures up to 10 hours unless otherwise noted.

[‡]Health effects cited are for humans unless otherwise noted.

Chronic lung disease (silicosis)	Periodic chest X-ray and pulmonary function testing required
Respiratory irritation	Prevent skin and eye contact
Nervous system effects; eye and respiratory system irritation; reproductive system effects	Prevent skin contact; warn workers of possible adverse reproductive effects
Respiratory effects	Pulmonary function testing required
Pulmonary irritation	Prevent skin and eye contact
Potential for cancer in humans; has produced tumors at many sites in animals; chloracne	None
Central nervous system effects; possible liver and kidney effects	Exposures should be minimized because of structural similarity to carcinogenic chloroethanes
Potential for cancer in humans; has produced tumors of the liver in animals; liver, gastrointestinal, and nervous system effects	Prevent skin contact; blood monitoring required
Potential for cancer in humans; has produced tumors of the liver in animals	None

the testimony was presented. NIOSH recommendations were originally noted.

Potential Hazard and Source for NIOSH Recommendation*	OSHA PEL/Standard	REL [†] /Other Recommendations
Thiols: n-alkane mono thiols, cyclohexanethiol, and benzenethiol (September 1978)	Butylmercaptan (1-butane-thiol), 10 ppm (35 mg/m ³); 8-hr TWA; ethylmercaptan (1-ethanethiol) 10 ppm (25 mg/m ³) ceiling; methylmercaptan (1-methanethiol), 10 ppm (20 mg/m ³) ceiling	All values are 15 min ceilings in ppm (mg/m ³): 1-methanethiol, 0.5 (1.0); 1-ethanethiol, 0.5 (1.3); 1-propanethiol, 0.5 (1.6); 1-butane-thiol, 0.5 (1.8); 1-pentanethiol, 0.5 (2.1); 1-hexanethiol, 0.5 (2.4); 1-heptanethiol, 0.5 (2.7); 1-octanethiol, 0.5 (3.0); 1-nonenethiol, 0.5 (3.3); 1-decanethiol, 0.5 (3.6); 1-undecanethiol, 0.5 (3.9); 1-dodecanethiol, 0.5 (4.1); 1-hexadecanethiol, 0.5 (5.3); 1-octadecanethiol, 0.5 (5.9); cyclohexanethiol, 0.5 (2.4); benzenethiol, 0.1 (0.5). Control mixtures of thiols by calculating equivalent concentrations
o-Tolidine (August 1978)	None	Ca; 20 µg/m ³ ceiling (60 min)
o-Tolidine-based dyes (joint NIOSH/OSHA Health Hazard Alert, December 1980)	None	Ca; handle with caution in the workplace; minimize exposure
Toluene (January 1974)	200 ppm, 8-hr TWA; 300 ppm acceptable ceiling; 500 ppm maximum ceiling (10 min)	100 ppm (375 mg/m ³), 8-hr TWA; 200 ppm (750 mg/m ³) ceiling (10 min)
Toluene diisocyanate (July 1973; revised, see Diisocyanates, September 1978)	0.02 ppm (0.14 mg/m ³) ceiling	0.005 ppm (0.036 mg/m ³) TWA; 0.02 ppm (0.14 mg/m ³) ceiling (10 min)

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Health Effect(s) Considered ^a	Comments
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Irritation; eye, skin, blood, and nervous system effects	Blood and urine monitoring required; prevent skin contact
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Bladder cancer, nasal irritation	Urine testing required; quarterly urine monitoring recommended; prevent skin contact
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Bladder cancer	Substitute less toxic dyes wherever possible
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Central nervous system depressant	None
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Respiratory effects	Periodic chest X-ray, blood tests, pulmonary function testing required
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1,1,1-Trichloroethane (July 1976; revised August 1978 in CIB)	350 ppm (1,900 mg/m ³), 8-hr TWA	350 ppm (1,910 mg/m ³) c (15 min); action level set 200 ppm (1,091 mg/m ³) T handles with caution
1,1,2-Trichloroethane (CIB, August 1978)	10 ppm (45 mg/m ³), 8-hr TWA (Skin)	Ca; reduce exposure to lowest feasible concentra
Trichloroethylene (July 1973; revised in Special Hazard Review, January 1978)	100 ppm, 8-hr TWA; 200 ppm acceptable ceiling; 300 ppm maximum ceiling (5 min in 2 hr)	Ca; 25 ppm TWA
Trimellitic anhydride (CIB, February 1978)	None	Handle in the workplace extremely toxic substanc
Tungsten and cemented tungsten carbide (September 1977)	None	Insoluble tungsten, 5 mg W/m ³ TWA; soluble tungsten, 1 mg W/m ³ TWA; dust of cemented tungste carbide (containing >2% cobalt), 0.1 mg Co/m ³ TWA; dust of cemented tungste carbide (containing >0.3% nickel), 15 µg Ni/m ³ TWA
Ultraviolet radiation (December 1972)	None	For spectral region of 315-400 nm: for periods sec, 1.0 mW/cm ² ; for per <1,000 sec, 1,000 mW-s (1.0 J/cm ²). For spectral region of 200-315 nm: other criteria document

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(m^3) ceiling set at (m^3) TWA; centration lace as an stance ngsten >2% m^3 TWA; ngsten >0.3% TWA of iodide >1,000 or periods W-sec/cm 2 ctral m: consult	Central nervous system, liver, and cardiovascular effects	Medical warning of possible congenital abnormalities required; structurally similar to carcinogenic chloroethanes
Potential for cancer in humans; has produced liver tumors in animals; central nervous system effects	None	
Potential for cancer in humans; has produced liver tumors in animals; central nervous system effects		Warn workers of hazards; 25 ppm level can be achieved by use of existing engineering control technology
Pulmonary edema; immuno- logic sensitization; irritation of pulmonary tract, eyes, nose, and skin		Minimize workplace levels
Lung and skin effects		Pulmonary function testing and periodic chest X-ray required
Skin and eye effects		Avoid skin and eye contact

ed or when the testimony was presented. NIOSH recommendations were originally
otherwise noted.

Potential Hazard and Source for NIOSH Recommendation*	OSHA PEL/Standard	REL [†] /Other Recommendations
Vanadium (August 1977)	Vanadium pentoxide dust, 0.5 mg/m ³ ceiling; vanadium pentoxide fume, 0.1 mg/m ³ ceiling; ferrovanadium, 1 mg/m ³ , 8-hr TWA	Vanadium compounds, 0.05 mg V/m ³ ceiling (15 min); metallic vanadium and vanadium carbide, 1 mg V/m ³ TWA
Vibration syndrome (CIB, March 1983)	None	Redesign jobs to minimize use of vibrating hand tools; redesign powered hand tools to minimize vibration
Vinyl acetate (September 1978)	None	4 ppm (15 mg/m ³) ceiling (15 min)
Vinyl chloride (March 1974; reaffirmed June 1974 as part of NIOSH testimony at OSHA hearing)	1 ppm, 8-hr TWA; 5 ppm ceiling (15 min); 29 CFR 1910.1017	Ca; lowest reliably detectable concentration
Vinyl halides (September 1978)	None except for vinyl chloride	Ca; vinyl halides to be controlled as specified for vinyl chloride in 29 CFR 1910.1017, with eventual goal of zero exposure
Waste anesthetic gases and vapors (March 1977)	None for substances when used as anesthetic agents	Halogenated anesthetic gases; 2 ppm ceiling (1 hr); nitrous oxide, 25 ppm TWA during periods of use

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Health Effect(s) Considered ¹	Comments
Eye, skin, and lung effects	Pulmonary function testing and periodic chest X-ray required
Vibration syndrome; adverse circulatory and neural effects in the fingers	None
Irritation	None
Liver cancer	Liver function testing required
Vinyl chloride has produced liver cancer in humans; other vinyl halides have produced liver and kidney tumors in animals	Vinyl halides include vinyl chloride, vinylidene chloride, vinyl bromide, vinyl fluoride, and vinylidene fluoride monomers
Reproductive system effects and audio-visual performance decrements	Halogenated anesthetic agents include chloroform, enflurane, fluoxetine, halothane, methoxyflurane, and trichloroethylene; advise workers of potential effects; document abnormal outcomes of pregnancies of workers or spouses

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Welding, brazing,
and thermal cutting
(April 1988)

Many aspects are covered under the following regulations: general industry (29 CFR 1910), construction (29 CFR 1926), ship repairing (29 CFR 1915), ship building (29 CFR 1916), longshoring (29 CFR 1917)

Existing RELs for specific chemical and physical agents are applicable; consider these RELs upper bounds of exposure; implement recommendations emphasizing good work practices, engineering controls, medical monitoring

Xylene
(May 1975)

100 ppm (435 mg/m³),
8-hr TWA

100 ppm (434 mg/m³)
200 ppm (868 mg/m³)
(10 min)

Zinc oxide
(October 1975)

5 mg/m³, 8-hr TWA
(as ZnO fume)

5 mg ZnO/m³ TWA;
15 mg ZnO/m³ ceiling

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[‡]Health effects cited are for humans unless otherwise noted.

specific physical agents	Cancer, respiratory disease, heat-induced illness, noise-induced hearing loss, eye injuries, traumatic and ergonomic injuries	None
g/m ³) TWA; g/m ³) ceiling	Central nervous system depressant; respiratory irritation	None
VA; ceiling (15 min)	Metal fume fever	None

ished or when the testimony was presented. NIOSH recommendations were originally less otherwise noted.

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★U.S. Government Printing Office: 1988-530-111/81519 Region IV

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HEALTH & HUMAN SERVICES
Public Health Service
Centers for Disease Control
Atlanta, GA 30333

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HHS Publication No. (CDC) 88-8017

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